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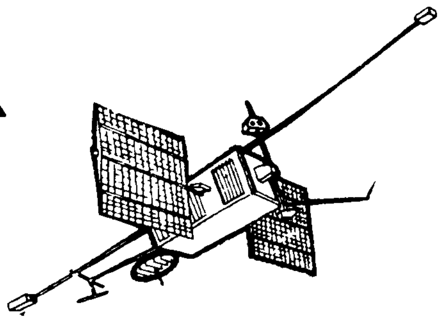
NASA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

TELS. WO 2-4155
WO 3-6925

FOR RELEASE: FRIDAY P.M.
July 21, 1967

RELEASE NO: 67-187



PROJECT: OGO-D

(To be launched no earlier than July 26, 1967)

CONTENTS

NEWS

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POLAR ORBITING
GEOPHYSICAL
LAB LAUNCH SET

The fourth Orbiting Geophysical Observatory (OGO-D) will be launched into a nearly polar orbit by the National Aeronautics and Space Administration from the Western Test Range in California, no earlier than July 26.

The OGO-D spacecraft will study the relationship between our Sun and the nature of the Earth's environment during a period of increased solar activity.

Particular emphasis will be placed on the interrelationships between particle activity, aurora and airglow, the geomagnetic field, the neutral and ionized composition of the atmosphere, and the electromagnetic energy sources contributing to ionization and atmospheric heating.

OGO-D's (OGO IV in orbit) nearly polar orbit will provide scientific data over the polar regions where the Earth's magnetic field lines extend to great distances from the Earth, and where special phenomena such as auroras and low energy solar particles and cosmic rays can be observed.

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The 20 experiments carried in the 1,240-pound, insect-shaped satellite will also obtain global data over a complete range of latitudes extending from the equator to the poles.

A Thrust-Augmented Thor Agena D launch vehicle will inject OGO-D into an orbit ranging from 259 statute miles (perigee) to 575 statute miles (apogee). The planned orbital period will be 98.1 minutes and the inclination angle to the equator is 86 degrees.

The OGO-D experiments, weighing 274 pounds, were contributed by eleven United States universities, one foreign university, two NASA field centers and two government agencies.

NASA's OGO program consists of six spacecraft. OGOs I, II and III were launched September, 1964, October, 1965, and June, 1966 respectively. Three of the missions call for polar orbits and three highly elliptical orbits.

Data obtained by OGO-D will be correlated with results from OGO I and III (which are in highly elliptical orbits ranging from 170 miles to about 90,000 statute miles) and OGO II, whose polar orbit is almost identical to the planned OGO-D orbit.

Because a detailed scientific picture of the Earth's environment continually changes, the data from several OGO satellites will help scientists to distinguish changes due to time, from changes due to position.

As an example, during a two-week period in November of 1966, the three satellites were operated simultaneously and data were obtained from 46 experiments at the same time.

OGO-I and II are still operating part time in a spin-stabilized mode and returning useful scientific data from 12 of the 20 OGO I experiments and half (10) of the OGO II experiments.

OGO III operated in a fully stabilized mode (all three axes) for 46 days and is now operating in a secondary spin stabilization mode with 16 of 21 experiments still working after one year.

To date, the three OGO spacecraft have operated for over 30,000 satellite hours, and have collected over 450,000 experiment hours of data which scientists hope may eventually unlock some of the mysteries of the Earth's environment.

Data from OGO satellites has provided new knowledge concerning: the magnetispheric boundary, the transition region, the bow shock, the magnetospheric tail, the auroral regions, and the upper atmosphere.

These data are pointing the way to the resolution of important questions in energetic particle and wave propagation physics, ionic plasma physics, and photochemistry.

The most important feature of the OGO results has been the high data rate, which has provided scientists with a sort of moving picture of the Earth's environment. Previous results from smaller scientific satellites, at lower data rates, were equivalent to a static picture, or snapshot view.

OGO data shows the shock and magnetospheric boundary as rapidly fluctuating regions of intense activity. As many as 10-20 crossings of the bow shock are observed on a single satellite pass.

Previously, it was thought that the solar wind emanating from the Sun did not penetrate into the magnetosphere. OGO has found evidence of boundary instability which could explain how particles get into the magnetosphere.

In the magnetospheric tail, rapid changes in the intensity and flux of energetic particles have been observed following magnetic storms. Sudden collapse of a portion of the magnetic field in the tail and distortions of the day-side magnetosphere boundary have been correlated with ground-observed polar cap magnetic changes which generally precede auroral activity, and have provided the first evidence of a common mechanism for major changes in the magnetosphere and in the polar region.

Measurements obtained over the poles are providing new insight to the well-known auroral displays. Large changes in the intensity of magnetic field fluctuations, in a burst-like form, have been found in the vicinity of the auroral zones.

The global magnetic survey data obtained by OGO, as part of the United States' commitment to the IQSY-World Magnetic Survey, has made major improvements in field maps prepared from earlier data. These data show that future mathematical models will have to include corrections for a non-spherical Earth.

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Other results relate to the clear identification of the controlling influence of the geomagnetic field on ion population. These findings which correlate well with electron data derived from very low frequency noise, or whistlers, observed on the ground and data from other OGO experiments indicate the existence of a new region, the plasmapause, where there is a sudden decrease in electron and ion concentration. These results have a very significant bearing on our understanding of the upper atmosphere.

Already, over 200 scientific and engineering papers and reports based on OGO missions have been presented at symposia or published.

In orbit, OGO-D resembles a giant insect. It gets this appearance from arm and leg appearing booms, antennas and wing-like solar paddles which jut from the rectangular box-shaped main structure.

The sophisticated OGO design was necessary so that the satellite could simultaneously take geophysical measurements, point toward Earth, point instruments at the Sun, and point instruments into the orbital plane of the spacecraft.

The observatory, with booms and solar panels fully extended, is 49 feet long, about 20 feet wide and contains more than 100,000 separate parts. During the launch phase, these appendages are folded against the main body like a closed jackknife.

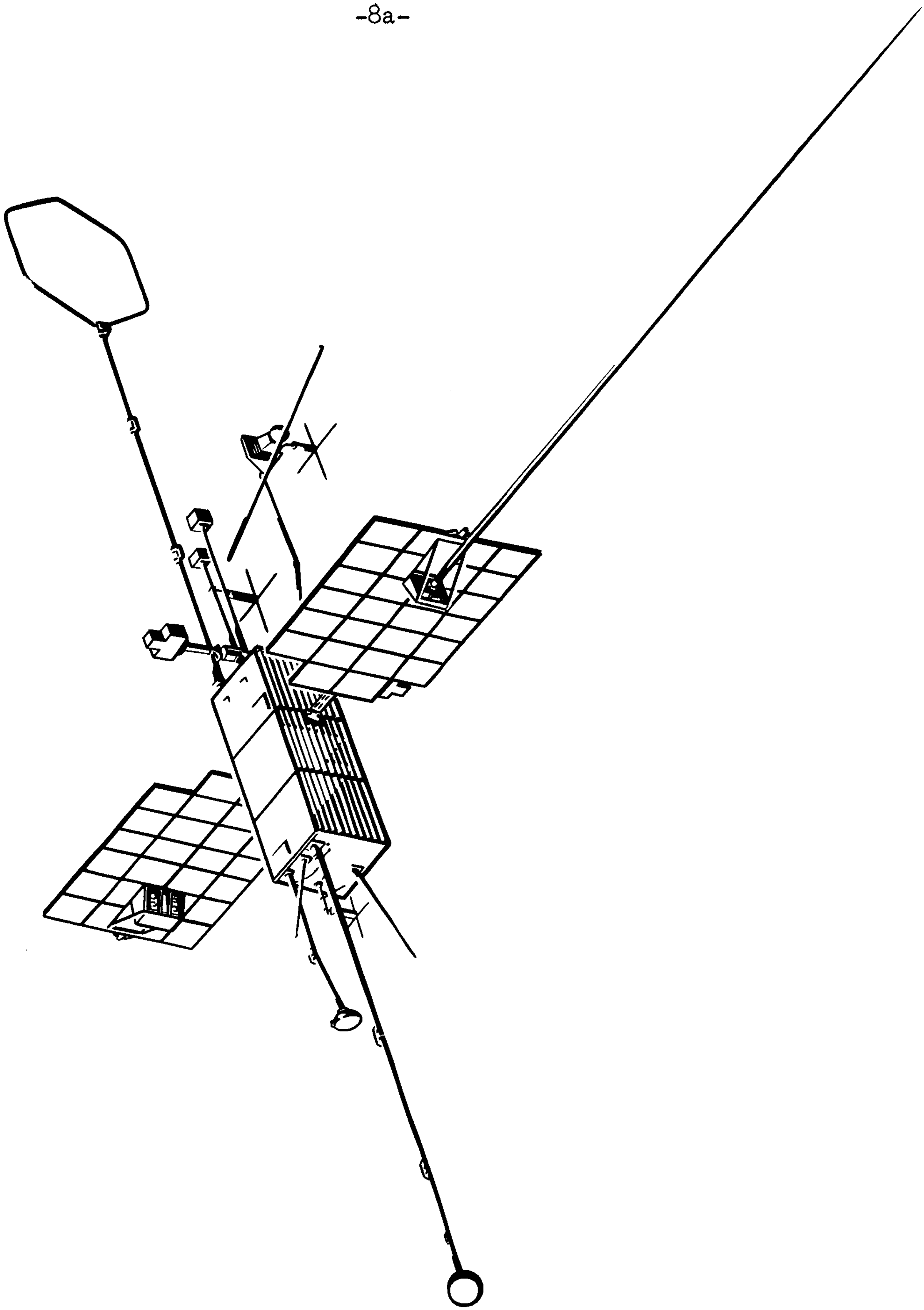
To obtain data from 25 per cent of the OGO-D experiments, one side of the spacecraft must point toward Earth. Thus, the satellite utilizes an attitude control system which keeps OGO-D stabilized in all three axes (pitch, yaw and roll). The combination of horizon scanners, advanced electronics, gas jet system and electrically driven flywheels (which act as gyros) are designed to keep the satellite stable.

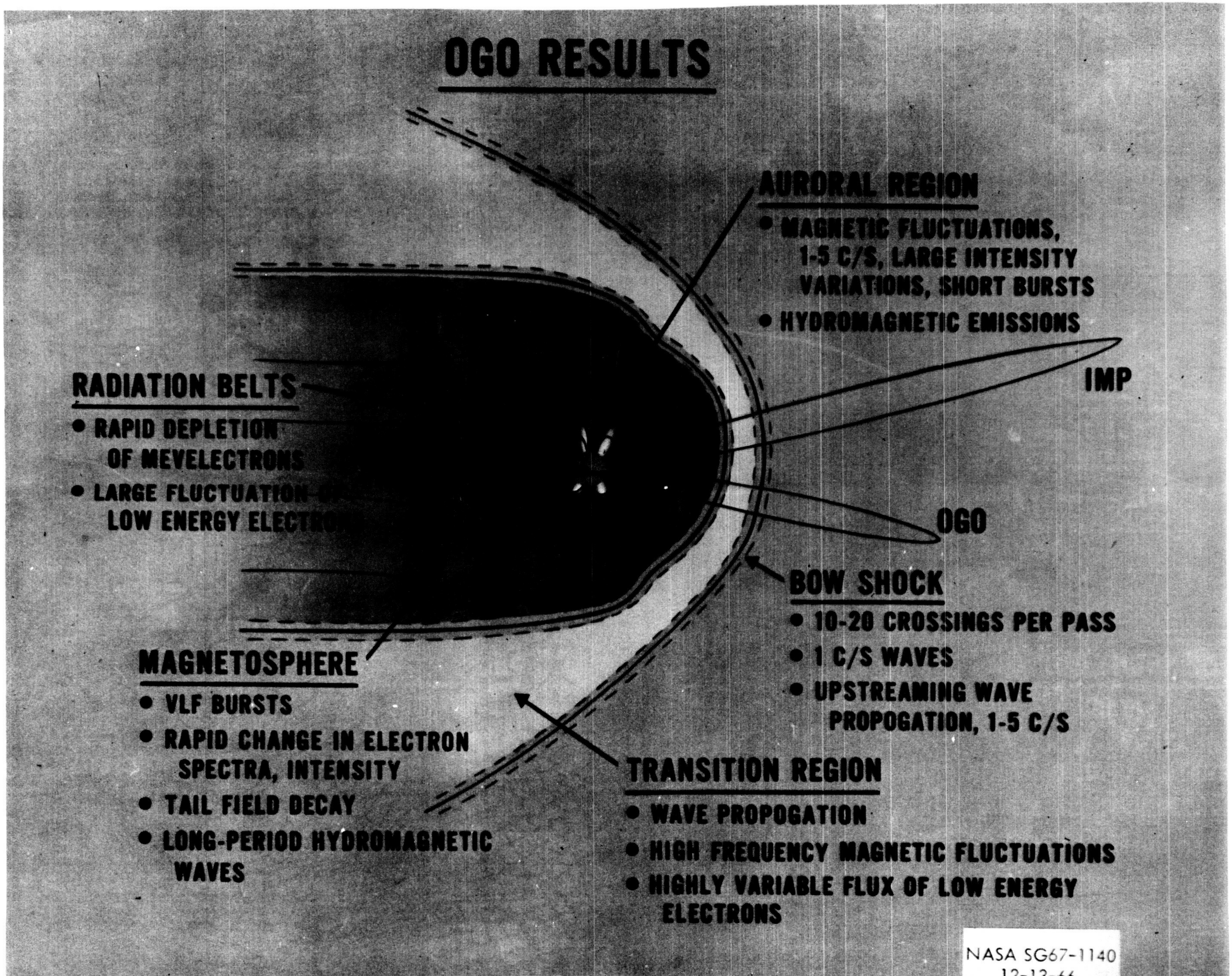
The Orbiting Geophysical Observatory program is part of NASA's scientific space exploration study conducted by the Office of Space Science and Applications, Washington, D. C. OGO project management rests with the Goddard Space Flight Center, Greenbelt, Md.

NASA's Lewis Research Center, Cleveland, Ohio is responsible for the Thrust-Augmented Thor Agena D launch vehicle. Launch operations will be performed by the Air Force's 6595th Aerospace Test Wing under the technical direction of NASA's Kennedy Space Center Unmanned Launch Operations.

OGO prime contractor is TRW Systems, Redondo Beach, Calif. Douglas Aircraft, Santa Monica, Calif., developed the Thor and Lockheed Missile and Space Corp., Sunnyvale, Calif., the Agena stage. Hundreds of subcontractors and vendors across the nation have provided various subsystems and electronics for the satellite.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)




OGO RESULTS
AURORAL REGION
• MAGNETIC FLUCTUATIONS, 1-5 C/S, LARGE INTENSITY VARIATIONS, SHORT BURSTS
• HYDROMAGNETIC EMISSIONS
IMP
RADIATION BELTS
• RAPID DEPLETION OF MEVELECTRONS
• LARGE FLUCTUATION
LOW ENERGY ELECTR
OGO
BOW SHOCK
• 10-20 CROSSINGS PER PASS
• 1 C/S WAVES
• UPSTREAMING WAVE PROPOGATION, 1-5 C/S
MAGNETOSPHERE
• VLF BURSTS
• RAPID CHANGE IN ELECTRON SPECTRA, INTENSITY
• TAIL FIELD DECAY
• LONG-PERIOD HYDROMAGNETIC WAVES
TRANSITION REGION
• WAVE PROPOGATION
• HIGH FREQUENCY MAGNETIC FLUCTUATIONS
• HIGHLY VARIABLE FLUX OF LOW ENERGY ELECTRONS
NASA SG67-1140
12-13-66

OGO-D FACT SHEET

SPACECRAFT:

Shape	Main body is rectangular shape, six feet long, three feet wide, three feet high; with appendages deployed, spacecraft looks like giant insect, is 49 feet long and 20 feet wide.
Overall Weight	1,240 pounds
Experiment Weight	274 pounds
Appendages	Two 22-foot booms; four four-foot booms; two solar panels, six feet wide, seven and one-half feet long with approximately 80 square feet covered with 32,928 N/P cells; two orbital plane experiment packages, 18 inches long, 10 inches wide and 10 inches deep.
Power Supply	Solar supply to two 28-volt nickel cadmium batteries using unregulated direct current with maximum capability of about 560 watts.
Experiments	Twenty experiments supplied by 11 United States universities, 1 foreign university, 2 NASA field centers and 2 government agencies.

LAUNCH INFORMATION:

Vehicle	Thrust-Augmented Thor (TAT)-Agena D.
Launch Pad	Space Launch Complex 2-East, Western Test Range, Lompoc, Calif.
Launch Azimuth	176 degrees True
Date	No earlier than July 26

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Time . . . . .10:20 a.m., EDT

Window . . . . .About one hour

NOMINAL ORBITAL ELEMENTS:

Apogee . . . . .575 statute miles

Perigee . . . . 259 statute miles

Period . . . . .98.1 minutes

Inclination . . . . 86 degrees

Velocity (at Agena burnout) . 17,398 miles per hour

TRACKING AND DATA ACQUISITION STATIONS

NASA's Space Tracking and Data Acquisition Network (STADAN) is responsible for tracking, telemetry and data processing support for the OGO mission. STADAN is under operational responsibility and supervision of the Goddard Space Flight Center, Greenbelt, Md. Facilities in Australia are operated for NASA by the Australian Department of Supply. Facilities in the Republic of South Africa are operated for NASA by the South African Council for Scientific and Industrial Research.

OBSERVATORY MANAGEMENT: . . . . . .Office of Space Science and Applications, NASA Headquarters, and NASA's Goddard Space Flight Center.

LAUNCH VEHICLE MANAGEMENT: . . . . NASA/Lewis Research Center

LAUNCH OPERATIONS: . . . . U. S. Air Force 6595th Aerospace Test Wing under the technical supervision of the NASA/Kennedy Space Center Unmanned Launch Operations.

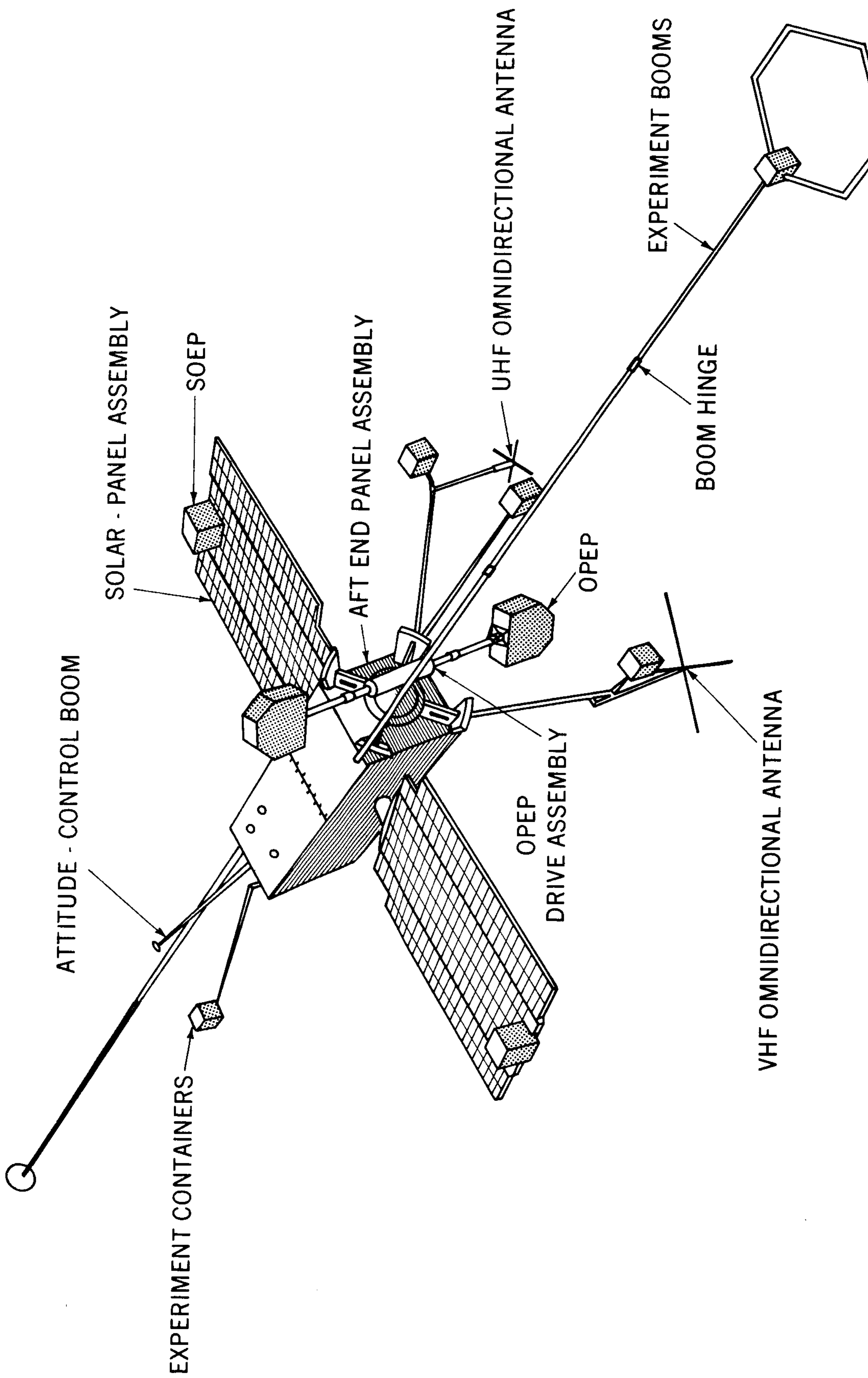
PRIME CONTRACTORS:

OGO-D Spacecraft . . . . . . .TRW Systems
Redondo Beach, Calif.

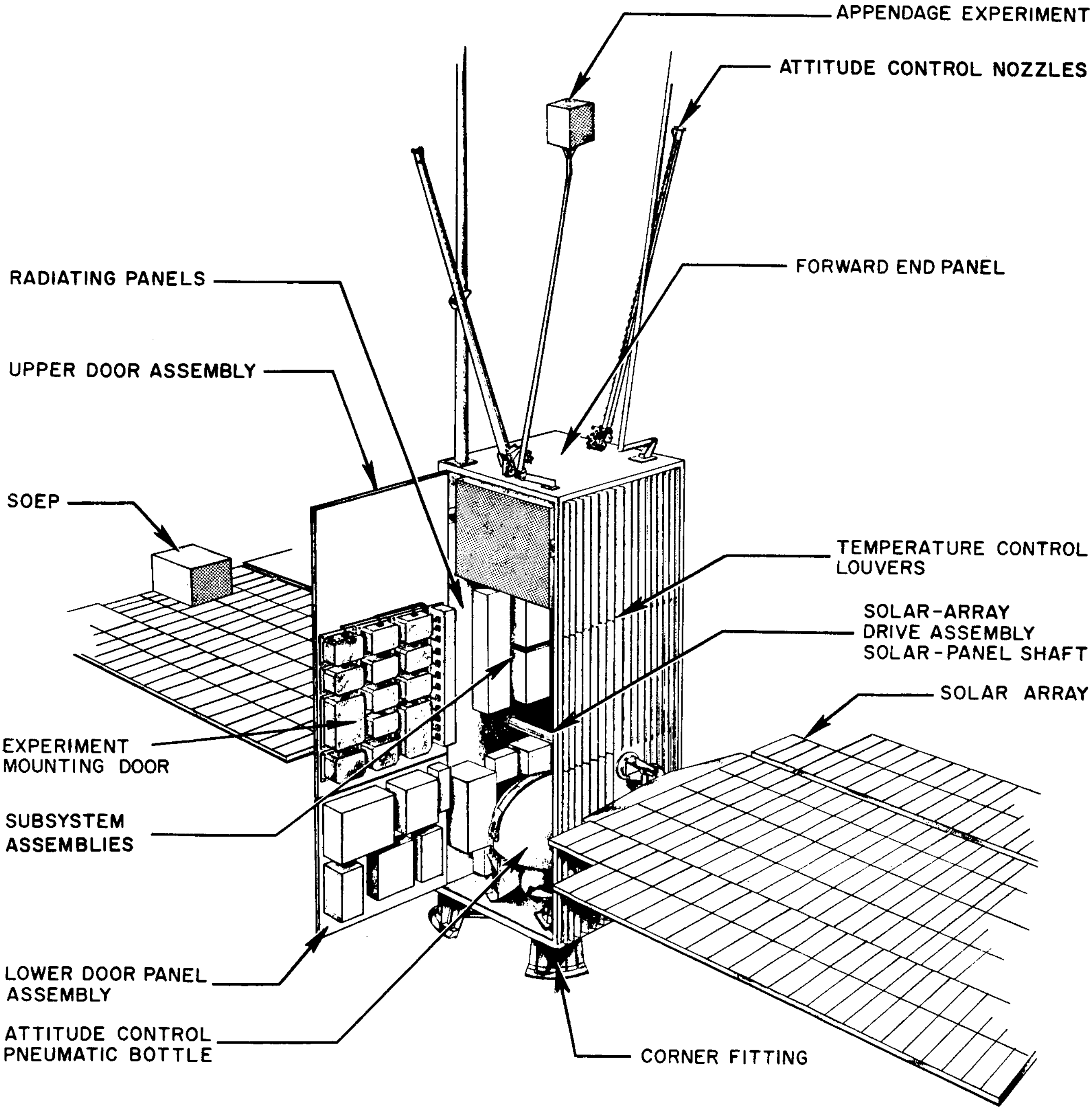
Thor Booster . . . . .Douglas Aircraft Co.
Santa Monica, Calif.

Agena Stage . . . . Lockheed Missile and Space Corp.
Sunnyvale, Calif.

OGO-D OBSERVATORY



FULLY DEPLOYED IN ORBIT



OGO-D MAIN BODY

OGO-D SPACECRAFT

OGO-D consists of a main body about six feet long, three feet deep and three feet wide. Attached to this section are 12 appendages.

Two 22-foot-long booms, longest on the satellite, carry experiment instrumentation which must be mounted away from the main body to avoid magnetic and other disturbing effects.

Four four-foot-long booms carry somewhat less sensitive experiments. OGO antennas are mounted away from the main body to take advantage of improved antenna patterns made possible by this technique.

Other external characteristics of the satellite include two box-like packages which carry experiments and can be rotated about an axis normal to the long axis of the satellite.

These packages, called the OPEPs (Orbital Plane Experiment Packages) are approximately 18 inches long, 10 inches wide and 10 inches deep. They carry experiments which will take readings in the orbital plane of the satellite.

Also mounted externally are attitude control jet nozzles which are placed on booms at one end of OGO. This placement increases the lever arm action and helps stabilize the satellite and reduce gas system weight.

Two large solar-cell panels convert solar energy into electrical power for satellite operation. The panels are mounted on a shaft running through the main body. They rotate automatically, and orientation of the satellite changes to permit them always to face the Sun.

Two solar oriented experiment packages (SOEPs) are mounted on the solar panels. These packages contain experiments designed to look toward the Sun.

Experiments not sensitive to the satellite's local environment are mounted inside two large hinged doors, much like refrigerator tray-doors. The doors can be opened for access to equipment or experiments.

Power Subsystem

The 33,000 solar cells mounted on the two solar arrays provide about 560 watts of electric power.

This is stored in two 12 ampere-hour nickel-cadmium batteries.

An average of 50 watts and a peak of 80 watts of power are reserved for experiments.

Attitude Control System

The OGO-D attitude control system is designed to keep the satellite stabilized in all three axes (pitch, yaw and roll), within two degrees of local vertical, five degrees of the Sun, and one side oriented toward Earth. The OPEPs are then oriented within five degrees of the orbital plane. The stabilization provides a platform for accurate directional measurements.

Basically, the control system consists of horizon scanners, servos, gas jets, electrically-driven flywheels and associated electronics.

Infrared horizon scanners control the bottom section of OGO-D's main body insuring that it always points toward Earth.

These scanners provide error signals to the inertial flywheels and gas jets which force the satellite to turn about in the roll and pitch axis.

Error signals for controlling yaw motion, and rotation of the power-producing solar panels, are controlled by Sun sensors situated on the ends of the panels.

The body yaw torque, produced by another inertia wheel and a set of gas jets, keeps the axis of the solar panels normal and the plane of the main body thermal radiation louvers parallel to the Sun line.

A third portion of the system controls the OPEPs to permit some of the experiments to look along the path of the satellite.

These experiments are directed forward in the plane of the orbit and normal to the observatory-Earth line. OPEPs can also scan across the orbital plane on command.

The OPEP sensor is a gyroscope operated in a gyrocompass mode. Its error voltage controls a drive which rotates the OPEPs with respect to the body.

Because of in-orbit experience with OGO I and II, and to increase the 46 day lifetime of the OGO III control system, NASA has made four major modifications on the OGO-D.

The first modification, a complete redesign of all magnetic amplifiers, resulted from the design deficiencies revealed by the failure of the OGO III attitude control subsystem power inverter.

A second modification involved several engineering steps to alleviate the effects of boom oscillations on the control subsystem and thus the satellite's stability. These changes were:

Incorporating reaction wheel drive delays for the roll and yaw channels;

Widening the solar array channel dead zone from one-half degree to one degree, as well as adding a drive delay; and

Coating the inboard elements of the long booms with a visco-elastic damping material.

The third modification of OGO-D was in the supply of control gas. The gas was changed from Argon to Krypton, a larger gas bottle was installed and pressure was increased from 3,000 pounds per square inch (psi) to 4,000 psi. This higher pressure increased the available impulse by 100 per cent from 900 lb. seconds to 1,800 lb. seconds.

This modification is required to compensate for the higher aerodynamic drag expected as a consequence of atmospheric heating as we approach maximum solar activity.

The fourth change incorporated in OGO-D was an improved nickel-cadmium battery.

Thermal Control System

A combination active and passive thermal control system regulates temperatures in the electronics system compartments of the observatory.

The temperatures of all assemblies within the main body are kept between about 41 to 95 degrees F. by sets of radiating panels and 112 temperature-actuated aluminum louvers located on three sides of the main body.

The temperatures of appendage packages containing experiment instruments are controlled by a similar thermal balance technique, except that louvers are not used. Heaters are used to maintain temperature limits when experiments are turned off.

This system is designed to keep the temperatures within the appendage containers within the range of about 32 to 104 degrees F.

Communications and Data Handling

The OGO communications and data handling system is designed to provide for tracking and command functions both for satellite housekeeping and experiment data, plus telemetry for 20 to 30 separate experiments.

The main telemetry is a wide-band PCM (pulse code modulation) system using a nine-bit word and capable of operating at three data rates which are selected by ground command.

The realtime data rate capability of the system ranges from 4,000 to 64,000 bits per second. Data stored in tape recorders at 4,000 bits per second plan back at 128,000 bits per second.

This system is composed of two redundant data handling units that operate with outputs transmitted to Earth in real time or are connected to one of the two tape recorders provided for storing up to six hours or 86,000,000 bits of data. These data are transmitted by four-watt wide-band transmitters at 400 mhz.

A special purpose telemetry system, capable of operating from an experiment whose output is an FM (Frequency Modulated) signal varying from up to five standard subcarrier oscillators.

For back-up, a second mode includes the transmission of the output of the wide-band telemetry system. The special purpose transmitter is rated at 0.5 watts at 400 mhz.

Data Processing

Data received on magnetic tape by the world-wide network of tracking and data acquisition stations (STADAN) will be forwarded to the OGO Control Center at the Goddard Space Flight Center.

Tracking data sent to Goddard will be used for computation of an accurate orbit for experimenters in data analysis and for spacecraft operations.

Taped data will be processed by high-speed computers. When the processing is completed, digital computer tapes will be produced for each experimenter.

These tapes will contain data from each individual experiment, necessary timing information, as well as data on spacecraft temperatures, voltages, and orbital data -- the standard housekeeping information.

The production data processing conducted at Goddard will be basically a computer sorting operation, providing experimenters with raw data from their experiments. Following the necessary analysis and evaluation by experimenters, data for the scientific community will be published in scientific journals.

The data will also be submitted to the National Space Science Data Center at Goddard Space Flight Center for the use of other interested scientists.

OGO-D SCIENTIFIC OBJECTIVES AND EXPERIMENTS

The 274 pounds packed in the 20 experiments of the OGO-D spacecraft cover the broad spectrum of the space science disciplines, and are correlative investigations in solar, aeronomy, energetic particle, auroral and airglow physics.

The information collected by these various experiments should help in understanding the Earth's environment and the time-dependent relationship that exists in galactic, interplanetary and planetary events, with emphasis on solar-terrestrial interactions.

At the present time in space exploration, scientists know how to make many of the individual measurements of the magnetic field, particle flow, ionization, etc.

The important question facing space scientists concerns the interrelations between these quantities and the establishment of detailed cause-and-effect relationships.

An example is the desire of physicists to study the density and composition of the upper atmosphere, and the way the atmosphere is affected by radiation from the Sun and by energetic particles.

To obtain this type of information requires several coordinated experiments, and large data reduction systems (to turn the data into easy-to-understand language), which leads to the requirement of large scientific spacecraft in the OGO class.

Following are some of the OGO-D near-Earth areas of investigation:

- Atmospheric and ionospheric measurements;
- Auroral and airglow studies;
- Solar radiation experiments;
- Radio emission measurements;
- Magnetic field measurements;
- Cosmic ray experiments.

These investigations should help achieve some of the following objectives:

1. New knowledge on the latitude and time-dependent variations of the pressure, temperature, density and chemistry of the neutral atmosphere surrounding the Earth;

2. The relationship between solar X-ray and ultraviolet emissions and their effect on the Earth's ionosphere, atmosphere and airglow;

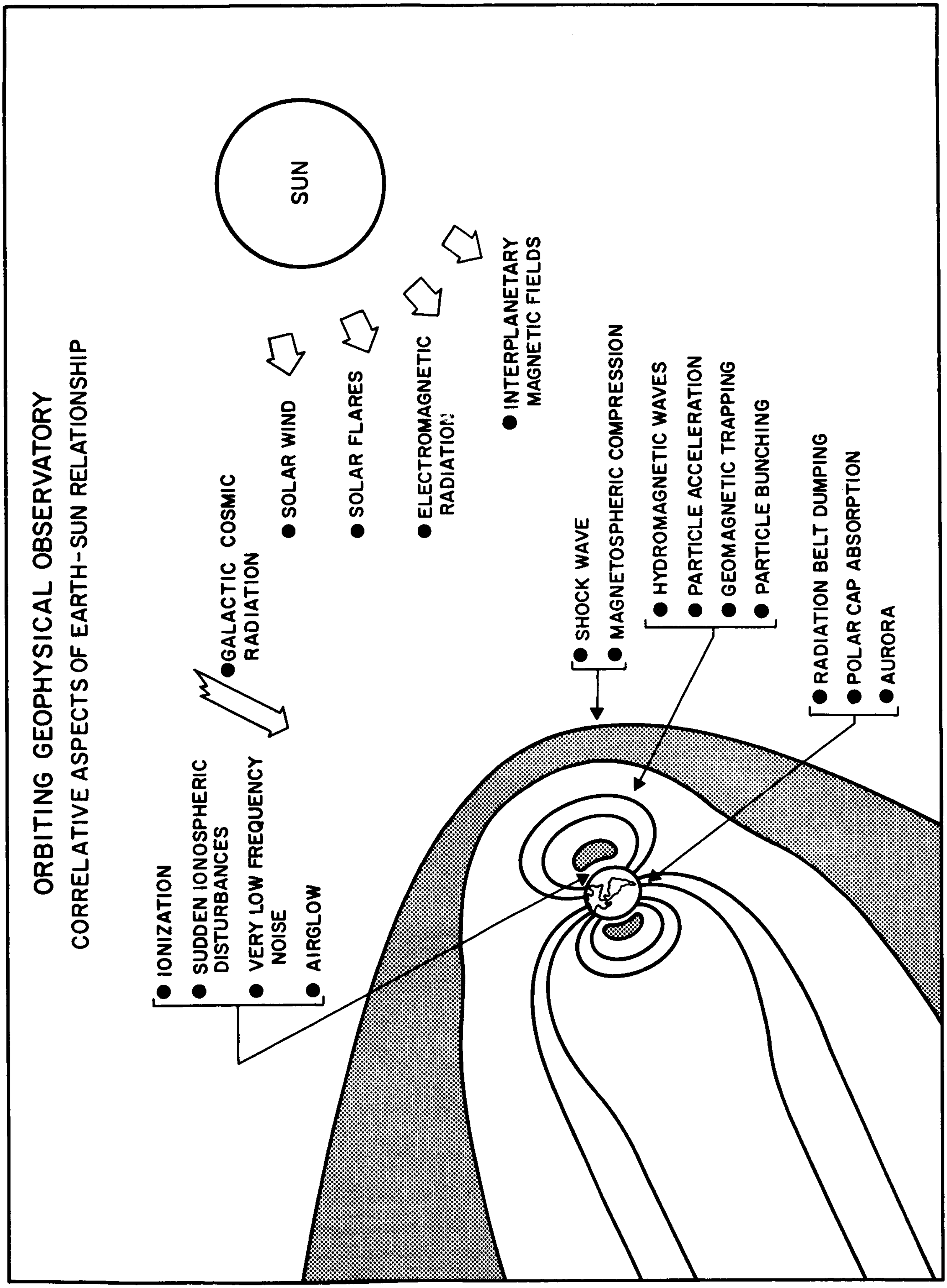
3. Further insight into the precipitation of energetic particles and the influx of solar cosmic rays into the auroral and polar regions and the occurence of aurora;

4. Measurement of solar ultraviolet and X-ray emissions during a period of moderate to high activity;

5. More information concerning low energy particles trapped in the Earth's magnetic field; the intensity of the magnetic field, and the overall relationship of the phenomena with very low frequency radio noise, ionospheric absorption and solar activity;

6. The definition of long-term changes in the geomagnetic field and further refinement of global magnetic field data as part of the United States' contribution to the World Magnetic Survey; and

7. A better understanding of interplanetary and galactic space as revealed by cosmic rays reaching the Earth from the Sun and from galactic sources.


ORBITING GEOPHYSICAL OBSERVATORY
CORRELATIVE ASPECTS OF EARTH-SUN RELATIONSHIP
SUN
GALACTIC COSMIC RADIATION
SOLAR WIND
SOLAR FLARES
ELECTROMAGNETIC RADIATION
INTERPLANETARY MAGNETIC FIELDS
IONIZATION
SUDDEN IONOSPHERIC DISTURBANCES
VERY LOW FREQUENCY NOISE
AIRGLOW
SHOCK WAVE
MAGNETOSPHERIC COMPRESSION
HYDROMAGNETIC WAVES
PARTICLE ACCELERATION
GEOMAGNETIC TRAPPING
PARTICLE BUNCHING
RADIATION BELT DUMPING
POLAR CAP ABSORPTION
AURORA

OGO-D SUMMARY OF EXPERIMENTS

Experimenter	Affiliation	Experiment
Dr. F.T. Haddock	University of Michigan, Ann Arbor	Radio Astronomy (2.5 mc)
Dr. R. A. Helliwell	Stanford University, Palo Alto, Calif.	VLF Noise and Propagation (0.03 - 100 kc)
Prof. M. G. Morgan	Dartmouth College, Hanover, N. H.	Whistlers and AF Electromagnetic Waves (0.5 - 20 kc)
Dr. E. J. Smith	JPL	Low Frequency Magnetic Field Fluctuations
Dr. R. E. Holzer	University of California Los Angeles	Low Frequency Magnetic Field Fluctuations
Dr. J. C. Cain	GSFC	Magnetic Field Survey
Dr. H. R. Anderson	Rice University, Houston, Texas	Cosmic Ray and Polar Region Ionization Study
H. V. Neher	California Institute of Technology, Pasadena, Calif.	Cosmic Ray and Polar Region Ionization Study
Dr. J. A. Simpson	Univ. of Chicago	Energetic Particles Survey
Dr. W. R. Webber	Univ. of Minnesota, Minneapolis	Galactic and Solar Cosmic Rays
Dr. J. A. Van Allen	Univ. of Iowa, Iowa City	Trapped and Precipating Particles
Dr. R. A. Hoffman	GSFC	Low Energy Auroral Particles

OGO-D SUMMARY OF EXPERIMENTS, CONT'D.

Experimenter	Affiliation	Experiment
Prof. J. Blamont	Univ. of Paris, Paris, France	Airglow and Aurora
Edith I. Reed	GSFC	Airglow and Aurora
Dr. P. W. Mange	U. S. Naval Research Laboratory, Washington, D.C.	Lyman Alpha and UV Airglow
Dr. C. A. Barth	Univ. of Colorado, Boulder	UV Spectra of the Earth's Atmosphere
Dr. L. A. Wallace	Kitt Peak National Observatory, Tucson, Ariz.	UV Spectra of the Earth's Atmosphere
Prof. L. Jones	Univ. of Michigan, Ann Arbor	Neutral Particle and Ion Measurements
H. A. Taylor	GSFC	Positive Ion Composition (1 - 45 AMU)
G. P. Newton	GSFC	Neutral Particle Measurements
Dr. C. S. Nilsson	Smithsonian Astrophysical Observatory, Cambridge, Mass.	Micrometeorites
J. L. Donley	GSFC	Ionospheric Composition and UV Flux
Dr. H. E. Hinteregger	Air Force Cambridge Research Laboratories, Bedford, Mass.	Solar UV Emissions
R. W. Kreplin	U. S. Naval Research Laboratory Washington, D. C.	**Solar X-ray Emissions**

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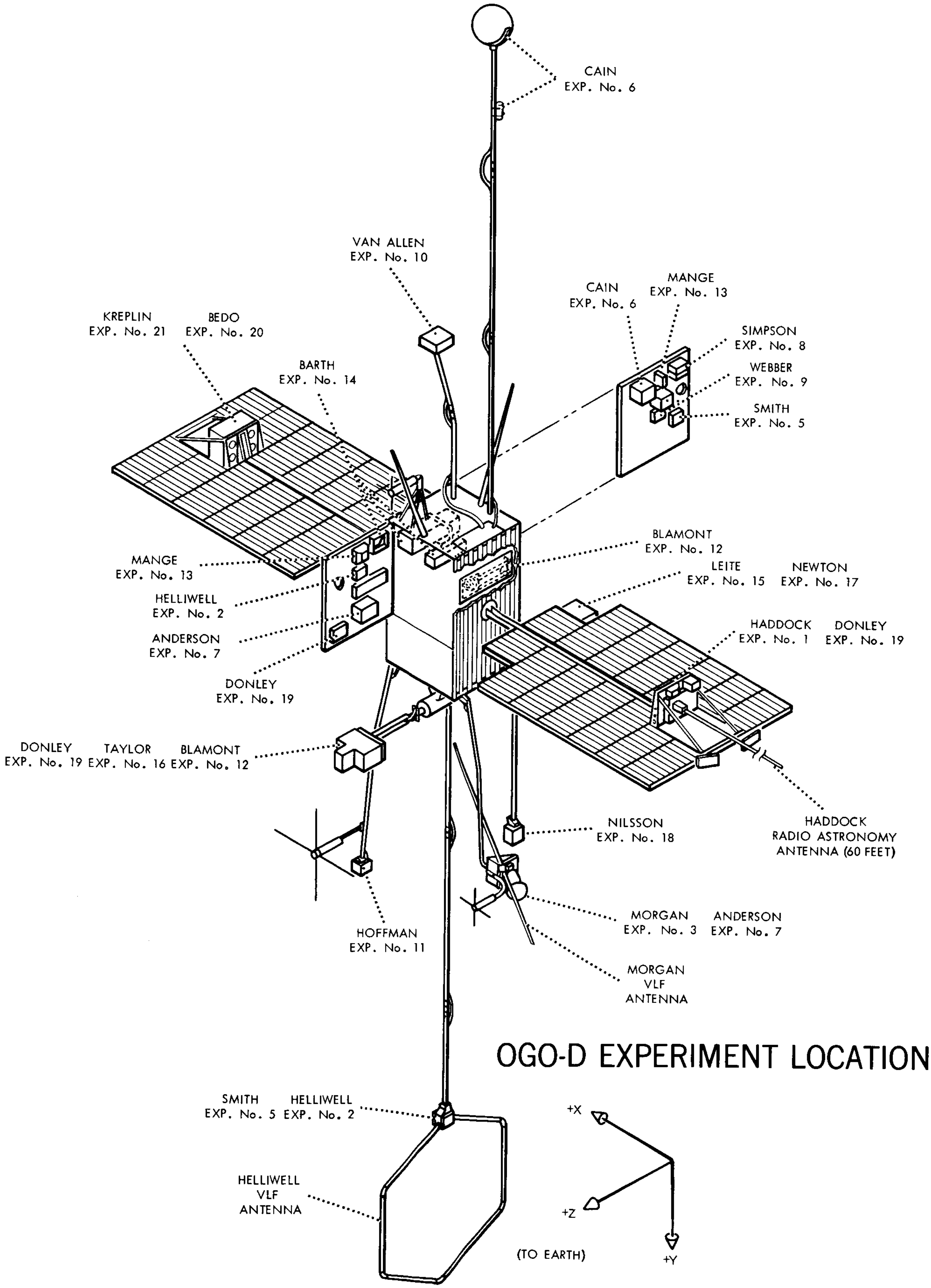

OGO-D EXPERIMENT LOCATIONS

ATMOSPHERIC AND IONOSPHERIC MEASUREMENTS

Neutral Particle Study - Goddard Space Flight Center

This experiment utilizes a Bayard-Alpert ionization gauge to directly measure neutral particle temperatures and densities to observe variances with longitude, latitude, altitude, day-night and seasonal changes. The data obtained will extend the knowledge of both the structure of the atmosphere and its thermal equilibrium.

The gauge resembles a conventional triode except the grid is positive and the anode is a small central rod. Electrons emitted from one of three redundant filaments ionize the neutral particles by collision. The electrons are then attracted to the grid, which repels the positive ions toward a collector to produce a measurable collector current which is proportional to the number density of the particles inside the gauge. The sensor, located in an OPEP, is scanned about the velocity vector. The variance of gauge pressure with rotation provides a measure of the neutral particle velocity distribution from which the temperature can be deduced. The gauge is sealed by a cover which is ejected in the post-launch period.

Neutral Particles and Ion Composition Study - University of Michigan

The objective of this experiment is to measure the ambient neutral gas and positive ion composition (1 to 50 AMU) of the atmosphere as a function of altitude and geographical position. The data will be an extension of composition measurements made primarily by sounding rocket techniques. Of prime interest is the dissociation and diffusive separation of the constituents of the atmosphere and the verification of a protonosphere.

The mass spectrometer utilized is the Paul massenfilter and is located in an OPEP. A varying quadrupole electrostatic field from four rods positioned 90° apart separates the various constituents of an incoming ionic gas into components of like charge-to-mass ratios. The separated components then drift out of the electrostatic field to a collector. The spectrometer alternates between positive ion and neutral particle measurements. Since neutral particles are insensitive to the electrostatic fields, a thermionic filament ionizes the ambient neutral particles before they enter the sensor.

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Positive Ion Composition - Goddard Space Flight Center

This experiment will obtain high resolution measurements ($\pm$ 1 AMU) of positive ion composition (1 to 45 AMU) within the Earth's lower ionosphere and the unexplored polar regions. These data will help identify and study suspected transition regions in the ionosphere where the predominent constituents may change.

Results of a similar experiment on previous OGO's have revealed a strong influence of the Earth's magnetic field upon the distribution of ions.

The instrument used is a Bennett r-f mass spectrometer located in the OPEP. The spectrometer consists of a tube with a number of plane-parallel knitted grids mounted at right angles to the axis of the tube. A-C and D-C fields accelerate the ions down the length of the tube toward a collector. To reach the collector, the ions must pass through a retarding potential. Only those ions satisfying the velocity and phase conditions established by the fields will receive sufficient energy from the fields to pass the retarding potential, and impinge on the collector.

Ionospheric Composition and Solar Ultraviolet Radiation - Goddard Space Flight Center

The scientific objectives of this experiment are to measure the solar ultraviolet radiation intensity, charge particle intensity, ion composition and temperature, and electron temperature. Measurement of these parameters will provide a test of empirical models of density distributions, will provide information on the behavior of the O^+-He^+ and He^+-H^+ transition regions, and will provide input data to the equations of continuity which relate solar radiation to the characteristics of the atmosphere. Theories of temperature equilibrium will also be tested and contributions to theories of atmospheric heating are expected.

The experimental approach to both the ionospheric measurements and solar ultraviolet measurements involves a retarding potential technique. Two identical sensors are employed. The ionospheric sensor is located in an OPEP and the solar radiation sensor in a SOEP. Each sensor consists of three circular grids and a collector mounted in planar parallel geometry. Switching of bias voltages and application of a stepping retarding potential to the outer grids varies the ion or electron flux. The collector current as a function of bias voltage and the retarding potential yields the desired parameters. In the ultraviolet sensor, the outer grids repel ambient particles and a ramp voltage applied to the inner grid retards the emission of photoelectrons from the collector. The energy spectrum of emitted electrons can be related to the total ultraviolet flux.

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Micrometeorites - Smithsonian Astrophysical Observatory

This experiment is one of a series of similar OGO experiments designed to provide a basic measure and understanding of the dust particle environment of the Earth. The experiment on OGO-D is designed specifically to measure the spatial density, velocity, and mass of dust particles in the mass range 10^{-13} to 10^{-9} grams. These measurements will be used to determine the orbits of these particles and to detect the existence of dust particle streams. Investigations of the importance of geomagnetic control on the dynamics of the dust particles and correlation of the various measurements with geophysical, geomagnetic and solar phenomena will also be attempted.

The particles are detected by four tubular detectors mounted on a short boom and aligned along the body axes of the observatory. An incoming particle first penetrates a thin film sensor which generates a plasma cloud used to start a 4 mc clock. The time-of-flight clock is stopped when the particle impacts on the rear sensor. This provides a measure of the velocity of the particle. A microphone attached to the rear sensor produces an output proportional to the momentum of the particle. Knowing the velocity, the mass of the particle can then be calculated. A knowledge of the orientation of the observatory defines the trajectory of the particle from which the approximate particle orbit can be computed.

AURORAL AND AIRGLOW STUDIES

Trapped and Precipitating Particles - University of Iowa

This experiment includes a comprehensive latitude and temporal study of the intensities and energy spectra of electrons and protons precipitating into the Earth's upper atmosphere (75 ev to 7500 ev). Information will also be obtained on the spatial, angular and temporal distribution of geomagnetically trapped proton and alpha particles.

The experiment is comprised of three sensors mounted on a short boom. A cylindrical electrostatic analyzer with channeltron detectors is used to detect low energy protons and electrons both separately and simultaneously. Electronic bias levels applied to two, thin, totally depleted, shielded, surface barrier silicon detectors provide four channels for measuring trapped alphas in the energy range of 1.5 to 10 Mev; and trapped protons and alphas in the energy range of 0.25 to 20 Mev and 0.40 to 200 Mev, respectively. A single thin window Geiger tube is provided for an integral measurement of electron flux above 40 kev.

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Low Energy Auroral Particles - Goddard Space Flight Center

Low energy auroral particles will be studied through high resolution measurments of the energy spectra and pitch angle distribution of electrons and protons (0.5 to 20 kev). Knowledge of low energy electrons and protons will contribute to understanding auroral and subauroral zone phenomena. Eight channel electron multipliers with cylindrical curved plate electrostatic analyzers are positioned on a short boom to locate four detectors (center energy: 0.55 Kev, 1.0 Kev, 4.3 Kev, 10.5 Kev) radially away from Earth and three detectors (center energy: 3.2 Kev) at angles of 30°, 60°, and 90°. The eighth detector will obtain background counts due to energetic particles and x-rays. By ground command, the polarity of the voltage on the analyzer plates is reversed allowing measurement of either electrons or protons.

Airglow and Auroral Study - University of Paris and Goddard Space Flight Center

The objective of this experiment is the observation of airglow and auroral activity by photometric measurement of emissions at the following wavelengths: 2630 A° (ultraviolet airglow); 3914 A° (visible aurora - molecular nitrogen ion emission); 5577 A° (airglow and aurora - green atomic oxygen emission); 5890 A° (airglow - sodium emission); 6225 A° (Hydroxyl radiation); 6300 A° (red atomic oxygen).

Photometers are mounted in the main body and the Orbital Plane Experiment Package (OPEP). All of the above spectral lines are sensed by the main body photometer oriented in the Earth direction. The 6300A line is also observed in the anti-Earth direction and by the OPEP photometer. In the main body photometer, the incident light is alternately directed through six filters corresponding to the six wavelengths by an automatic stepping mirror system.

The mirrors can be commanded to remain in any of the spectral positions for a more comprehensive study of the distribution of a particular line. The OPEP photometer views towards Earth and projects the light through a 6300A filter. A mirror scan system and OPEP rotation provide a two-dimensional sweep from the observatory's horizon to 30° in the direction of the Earth over an angular range of + 110°.

Lyman-Alpha and Ultraviolet Airglow Study - U.S. Naval Research Laboratory

This experiment will measure the flux of scattered hydrogen Lyman-Alpha radiation (1216A°) incident upon the Earth and the Earth albedo (ratio of reflected to incident radiation) at 1216°, 1230-1350A°, and 1350-1550A°. Measuring the excitation of ultraviolet fluorescence produced by particles provides an effective means of measuring the rate at which particles deliver energy to the atmosphere. A knowledge of the rate of energy input into the upper atmosphere as a function of time and location will greatly aid the understanding of both high altitude airglow emissions and of the origin of the electron component of the Van Allen belts. The Lyman-alpha measurement of atmospheric emissions can be related to spatial asymmetries in the atomic hydrogen content near the dissociation level, and will provide information concerning variations in the vertical transport of water vapor and methane.

Five ionization chambers and three cesium iodide photocells are used as detectors and are located in the main body. Two of the chambers are sensitive to Lyman-alpha radiation incident from the Earth and anti-Earth directions. The other six chambers are connected in two groups of three chambers to increase the sensitivity. Wavelength sensitivities are determined by window materials and the filler gas.

Ultraviolet Spectra of the Earth's Atmosphere - University of Colorado and Kitt Peak National Observatory

The scientific objective of this experiment is to measure the ultraviolet spectra of the Earth's upper atmosphere from 1100A° to 3400A°. These spectra will provide information on the nature and energy of the luminous particles in the aurora; the abundance and distribution of the molecular constituents in dayglow, atomic constituents in twilight glow, and the abundance and distribution of ozone.

The spectrometer consists of three basic parts: a telescope, monochrometer, and detectors. The telescope (Cassegrain) projects an image of the central portion of the Earth into an entrance slit of the monochrometer. The light is then separated by a ruled diffraction grating and projected onto an exit slit for selection of a minimum number of spectral lines for detection by photomultiplier tubes. The diffraction grating is automatically rotated to scan the spectrum.

SOLAR RADIATION EXPERIMENTS

Solar X-Ray Study - U.S. Naval Research Laboratory

Measuring the solar x-ray energy input to the Earth and its variations in order to understand the geophysical parameters of the upper atmosphere is the objective of this experiment. Changes in the solar radiation are one of the primary environmental influences affecting the ionosphere. In particular, solar x-ray bursts accompanying flares and active prominences are the direct cause of increased D region ionization, which in turn is responsible for radio fadeout, sudden cosmic noise absorption (SCNA), and other manifestations of the sudden ionospheric disturbance (SID) event. By establishing a set of x-ray indices of solar activity, correlation with other geophysical phenomena can be made. A study of time variations in solar events and perhaps a more quantitative method of classifying solar events can be made by use of these indices. (Size classification of flares provides a poor measure of the ionospheric effects of flares.) The time variation of emissions with the four wavelength bands monitored (0.5-3A°, 2-8A°, 8-16A°, 44-60A°) play an important role in the formation and variations in the D and E regions of the ionosphere and appear to constitute the predominent strongly variable component of solar radiation reaching the lower ionosphere.

Four ionization chambers are located in an SOEP. The chambers are band sensitive photometers, with the bandwidth defined by the properties of the window material and type of the gas within the chambers as well as other factors such as gas pressure, the chamber depth and mass absorption coefficient.

Solar Ultraviolet Emissions - Air Force Cambridge Research Laboratories

The objective of this experiment is to monitor radiation intensities in the extreme ultraviolet (170A° to 1700A°) portion of the solar spectrum. It will provide needed information on intensity levels and the temporal variations of these levels for correlative studies of UV emissions with ionospheric and atmospheric phenomena.

A scanning, grating spectrometer is located in a SOEP to maintain the optical axis of the instrument coincident with the mean solar vector. Radiation from the entire solar disk illuminates six gratings clamped together with parallel planes of dispersion and a common angle of incidence. The 170A° to 1700A° spectrum is divided into six overlapping ranges determined by the ruling (lines/mm) of the six gratings.

The dispersed radiations from the gratings are separated by a six-channel collimating slit system which is driven mechanically in 512 discrete steps through a 12-degree rotation. For each collimator position, only radiation of the wavelengths determined by the diffraction angle will be transmitted by the collimator to six photocathodes in two photomultiplier tubes. The output pulses from the photomultiplier tubes are related to the input solar flux at the appropriate wavelength. The scanning may be commanded to execute only 37 steps instead of the 512 about one of 32 selectable positions (wavelengths) for increased observation of temporal variations of intensities.

RADIO EMISSION MEASUREMENTS

VLF Noise and Propagations - Stanford University

The objectives of this experiment are to study VLF propagation, properties of the ionosphere, the origin of VLF ionospheric noise, and a synoptic noise survey in the frequency range 0.03-100 kc. The phenomena to be studied include: the terrestrial noise produced from such atmospherics as lightning noise, VLF emissions generated by moving charged particles, and the propagation of VLF signals from low frequency ground stations. As a result of a similar experiment flown on OGO-I and II the frequency limit of the OGO-III and OGO-D experiment was lowered and provision included for measurement of electric fields and electric antenna impedance. The earlier flights of this experiment have provided information on a new noise source deep in the magnetosphere, on proton and helium whistlers, on ducted and non-ducted propagation, and on propagation asymmetries.

The experiment instrumentation consists of five receivers: three step-frequency receivers, each covering one octave of the 0.2 to 100 kc range, a preamplifier which detects 0.03 to 0.20, a 0.2 to 12.5 kc broadband receiver, and a tunable narrowband receiver (14.7 to 26.1 kc) for reception of Navy VLF transmitters. The antenna, a 9.5 foot wide hexogonally shaped tube located at the end of a 20-foot boom, is to be released and inflated after the observatory is in orbit. The receivers and other instrumentation are located in the main body.

Whistlers and Audio-Frequency Electromagnetic Waves - Dartmouth College

The effects of the ionosphere on the propagation of whistlers and other audio-frequency (500 cps to 18 kc) electromagnetic waves of natural origin will be studied by this experiment. Problems to be studied included the question of the height of reflection of whistler echo trains and the variation of the ionospheric transmission loss of whistler-mode waves with time and frequency.

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To meet these objectives, most of the data from the observatory will be subjected to a detailed comparison with observations made simultaneously at a network of ground-based whistler stations.

A simple broadband (500 cps to 18 kc) receiver with adjustable gain is used. In orbit, a 10-foot dipole antenna will be deployed from a short boom.

Radio Astronomy - University of Michigan

The prime objective of this experiment is to map the brightness distribution of 2.5 Mc cosmic radio noise.

Other objectives are to observe certain ionospheric phenomena, one of which is a form of presumably locally generated noise in the topside ionosphere. Although the origin of this noise is not yet clear, it is possibly caused by Cerenkov radiation. Finally, it should be possible to detect tenuous ionized interstellar hydrogen by its absorption effects.

Instrumentation consists of a common preamplifier driving three separate output channels: 2.5 Mc and 2.0 Mc receivers and an antenna impedance measurement channel. A 60-foot tubular antenna of approximately 0.56 inches diameter will be deployed from the SOEP after the observatory is in orbit.

MAGNETIC FIELD MEASUREMENTS

Low-Frequency Magnetic Field Fluctuations - Jet Propulsion Laboratory and UCLA

The scientific objective is to investigate the naturally occurring magnetic field fluctuations in the low-audio and sub-audio frequency ranges (0.01-1000 cps). This includes signals which have been observed at the surface of the Earth and which are known to originate in or above the ionosphere; such as micropulsations (0.03 to 0.1 cps), hydromagnetic emissions (1 to 5 cps), and ELF emissions (200 to 1000 cps). It may also be possible to detect terrestrial ELF radio noise associated with lightning. Other signals which have not been observed at the surface of the Earth but which may reasonably be expected to occur in or above the ionosphere include magnetic variations associated with the intrusion of plasma clouds in the vicinity of the auroral zone, traveling ionospheric disturbances, and signals arising from the motion of the observatory with respect to magnetic fields created by the polar and equatorial electrojets. A similar experiment aboard the previous three OGO's has provided evidence of high frequency magnetic fluctuations near the magnetospheric boundary, at the bow shock and in the auroral zones.

The magnetometer is composed of a triaxial array of search coils situated at the end of one of the long booms for isolation from magnetic noise generated by the spacecraft and other experiments. This type of magnetometer is insensitive to fixed (d-c) magnetic fields, since a search coil basically consists of many thousands of turns of copper wire wound on a high mu core. An output from each of the three coils is proportional to the time rate of change of the ambient magnetic field.

World Magnetic Survey - Goddard Space Flight Center

A Rubidium Vapor magnetometer is used to obtain accurate scalar field measurements. Combined with vector field data extrapolated from surface and airborne measurements, these data will provide for a continued refinement of the mathematical description of the Earth's main field and a measurement of the contribution of the main field to the total magnetic field at any point in space. Time variances of the field will also be studied to derive the diurnal and storm variations as seen above the ionosphere. The orbit of the observatory should allow a comprehensive determination of the solar daily variations during both quiet and disturbed conditions as well as a study of such phenomena as the equatorial and auroral electrojets.

Initial global magnetic survey data were obtained with similar instrumentation aboard OGO-II as part of the United States' commitment for the IQSY-World Magnetic Survey. The OGO-D experiment should enhance these results, should allow some identification of short-period (several years) secular changes, and should, because of solar cycle variations, provide further insight on storm-like disturbances.

The magnetometer, located at the end of the other long boom, employs optical pumping of ribidium vapor cells. Accuracy is ± 1 gamma.

COSMIC RAY EXPERIMENTS

Cosmic Ray and Polar Ionization Study - Rice University and California Institute of Technology

The primary objective of this experiment is to study the behavior of cosmic rays in the Earth's magnetic field and to correlate this information with that obtained with the similar instruments mounted on balloons released at various latitudes.

Instrumentation consists of a 5-inch integrating ionization chamber filled with argon. The chamber's output voltage excursions are related to the incidence of cosmic radiation and the time interval between excursions of the intensity of radiation. The minimum detectable particle energies are 10 Mev for protons, 40 Mev for alpha particles, and 0.5 Mev for electrons.

Galactic and Solar Cosmic Ray Study - University of Minnesota

Data collected by this experiment will directly allow the determination of the energy spectrum of both galactic and solar protons over the energy range from 40 Mev to 1 Bev as well as other particles over a comparable energy per nucleon range. The direction of the particle influx will also be determined. By using the Earth's field as a magnetic analyzer, the energy range is extended to 30 Bev for protons over the equatorial regions. Also, the experiment functions as a high counting rate monitor for all radiation capable of penetrating 0.5 gm/cm^2.

The experiment consists of a mainbody detector oriented in the anti-Earth direction. The sensing device is composed of a scintillation crystal and a combination scintillation and Cerenkov detector. The minimum detectable energy is governed by the crystal thickness and the amount of shielding. All particles capable of producing a detectable light pulse are counted by the scintillation crystal. This provides a monitor for the total radiation. Otherwise, only coincident detector outputs are analyzed in order to measure the energy spectrum.

Energetic Particles Survey - University of Chicago

Protons in the energy spectrum from 0.5 Mev to 40 Mev and alpha particles between 2 Mev and 160 Mev are investigated. In a continued study of cosmic radiation, the objective of this experiment is to search for an extension of the spectra of untrapped protons and helium nuclei to very low energies and low intensity during the period of minimum solar activity and to provide evidence whether the radiation is of solar or galactic origin. These data and data obtained during solar flare events will be studied to determine the characteristics of storage and propagation of particles as modulated by the interplanetary magnetic fields during a relatively active Sun. Radiation belt proton and alpha fluxes at low altitude, and auroral protons in the energy range of the detectors will also be measured.

Two orthogonal telescopes are located in the mainbody on the anti-Earth side of the observatory. The vertical telescope consists of two solid state detectors mounted in a scintillator cup. Pulse height analysis and total count rate for various coincidence combinations yield the desired parameters. The horizontal telescope consists of a single solid state detector to measure proton-alpha flux isotropically incident to the Earth's magnetic field.

LAUNCH VEHICLE

The 1,215-pound OGO-D satellite will be launched by the Thrust-Augmented Thor-Agena-D into an elliptical near polar orbit. The orbit will be inclined to 86 degrees and has a period of 98.1 minutes.

The launch vehicle consists of a Thor (LV-2A) first stage, three strap on TX-33-52 solid rocket booster motors and an Agena-D second stage.

Only one burn of the Agena's 16,000 pound thrust engine is needed to place the OGO spacecraft in the required 259 by 575 mile orbit. In order to allow the spacecraft to remain in sunlight during its first 48 hours in space, the launch will take place during the first two hours immediately after dawn.

Because only a single burn of the Agena is required, injection of the spacecraft will occur within radar sight of WTR. Range telemetry ship coverage will overlap the land-based telemetry and be able to follow the spacecraft well beyond separation from the launch vehicle.

The Thor has two guidance systems. One is the Western Electric Company (WECO) Airborne Guidance Set Subsystem which is mounted in the Agena. This provides commands to the Thor beginning approximately 90 seconds after liftoff. The WECO system operates in conjunction with a WECO ground guidance radar. The WECO airborne set provides steering commands for the Thor during its burn period, discrete commands for Thor engine shutdown and Agena separation. The second system, a small programmer, can operate without any commands from outside of the Thor stage.

The Agena makes use of both the WECO system and an inertial reference subsystem that can operate without any commands from outside of the Agena.

During the Agena burn period, the WECO subsystem provides pitch and yaw steering commands to the Agena inertial reference subsystem. These are coupled with roll control signals from the Agena horizon sensor to generate control signals to gimbal the Agena engine and command Agena engine shutdown. During the subsequent coast, all Agena guidance is provided by the inertial reference system which uses roll and pitch signals from the horizon sensor as an attitude reference.

The NASA-Lewis Research Center, Cleveland, Ohio, through its Agena Project Office, has technical management responsibility for the launch vehicle. Lewis' job begins with defining the launch vehicle requirements and follows through the procurement, design, fabrication, test and integration, launch preparations and launch through injection of the spacecraft into the proper orbit. Launchings for Lewis are conducted by Unmanned Launch Operations, Kennedy Space Center.

FLIGHT SEQUENCE

The Thrust-Augmented Thor lifts off vertically with the main engine and the three strap-on solid motors firing. The vehicle follows a programmed roll to the flight azimuth of 177 degrees and a programmed pitchover to the proper trajectory. Both roll and pitchover are controlled by Thor's autopilot programmer. The solid strap-on rockets are depleted at 43 seconds into the flight and jettisoned at T plus 65 seconds. The radio guidance system begins to provide steering commands at T plus 90 seconds.

Main engine cutoff of the Thor occurs about 149 seconds into the flight based on altitude and velocity. MECO can be commanded by the WECO guidance system or the fuel-depletion switch. The vernier engines continue to fire for about 10 seconds after MECO.

Separation of the Agena and spacecraft from the Thor is initiated by discrete command from the WECO guidance system. This ignites the midbody primacord and the retrorockets in the adapter section. The spent booster is slowed and the Agena/OGO-D moves away. A pullaway plug at this point transfers WECO guidance to the Agena and connects the horizon sensor on the Agena to the roll gyro.

After coasting for nearly 60 seconds, the Agena engine is ignited for a burn of about 4 minutes. The clamshell shroud around the spacecraft is ejected about 10 seconds after Agena engine ignition.

Agena coasts for 99 seconds after engine cutoff. During the coast phase, the attitude of the Agena is stabilized by the inertial reference system which has now been disconnected from the WECO guidance.

At T plus 568 seconds the separation pyrotechnics are fired and the OGO observatory is freed from the Agena at a relative velocity of 4.5 feet per second. Three seconds after separation, the Agena is yawed 90 degrees so that it is essentially parallel to the Earth. The Agena maintains this attitude until battery power or guidance gas depletion. This removes it from possible conflict with the spacecraft.

Deployment of the OGO experiment booms solar arrays and antennas will begin automatically about 15 seconds after separation. Sun acquisition begins about two minutes after separation.

LAUNCH VEHICLE FACT SHEET

Liftoff weight 152,176 lbs.

Liftoff height 97 feet

	Thrust-Augmented Thor	Agena Stage
Weight (at liftoff)	132,000 lbs.	16,000 lbs.
Height	57 feet including adapter	21 feet
Diameter	5.33 feet upper diameter 8.00 feet lower diameter	5 feet
Propulsion Systems	Rocketdyne MB3-Block III main engine. Three Thiokol TX-33-52 solid motors	Bell 8096 main engine
Propellants	Main engine: liquid oxygen and RJ-1 fuel. Solids: polybutadiene acrylic acid co-polymer (PBAA) and ammonium perchlorate	unsymmetrical dimethylhydrazine (UDMH) and inhibited red fuming nitric acid (IRFNA)
Thrust	Main: 170,000 lbs. Strap-ons: 54,000 lbs. each	16,000 lbs. at altitude
Velocity at MECO	7,941 mph	17,397 mph
Prime Contractor	Douglas Aircraft Co., Santa Monica, Calif.	Lockheed Missiles & Space Co., Sunnyvale, Calif.

THRUST-AUGMENTED THOR-AGENA FLIGHT SEQUENCE

		Approximate Time (sec.)	Approximate Altitude (miles)
1.	Liftoff	0	
2.	Solid motor cutoff	43	7
3.	Solid motor ejection	65	14
4.	Thor main engine cutoff (MECO)	150	71
5.	Thor vernier engine cutoff (VECO)	159	81
6.	Thor-Agena separation	164	86.5
7.	Agena ignition	225	144
8.	Jettison nose fairing	235	152
9.	Agena engine cutoff	468	258

THE OGO-D PROGRAM TEAM

The following key officials are responsible for the Orbiting Geophysical Observatory satellite program:

NASA Headquarters

Dr. Homer E. Newell, Associate Administrator for Space Science and Applications

Jesse Mitchell, Director, Physics and Astronomy Programs

Marcel J. Aucremanne, Program Manager, Geophysical Observations

Thomas L. Fischetti, Associate Program Manager, OGO

Dr. Robert F. Fellows, Program Scientist

J. B. Mahon, Agena Program Manager

NASA-Goddard Space Flight Center

Dr. John F. Clark, Director

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Wilfred E. Scull, Project Manager

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NASA-Kennedy Space Center

Robert Gray, Assistant KSC Director for Unmanned Launch Operations

TRW Systems, Inc.

Dr. A. K. Thiel, Director, Spacecraft Systems Program Management

Ralph C. Turkolu, OGO Project Manager

Prime Contractor

Spacecraft design, development, fabrication and test, TRW Systems, Redondo Beach, Calif.

Major Subcontractors

Battery Cells, Gulton Industries, Inc., Metuchen, N.J.

Gyroscopes, Minneapolis-Honeywell Corp., Boston, Mass.

Horizon Scanners, American Standard, Advanced Technology Div., Mountain View, Calif.

Power Converters, ITT Industrial Products Div., San Fernando, Calif.

Reaction Wheels, Bendix Eclipse Pioneer Div., Teterboro, N.J.

Solar Cell Modules, TRW Systems, Inc., Redondo Beach, Calif.

Solar Cells, Hoffman Electronics Corp., El Monte, Calif.

Static Inverters, Kinetics Corp., Solana Beach, Calif.

Tape Recorders, RCA Astro-Electronics Div., Princeton, N.J.

Tape Transporters (in Ground Support Equipment), Ampex Corp., Redwood City, Calif.

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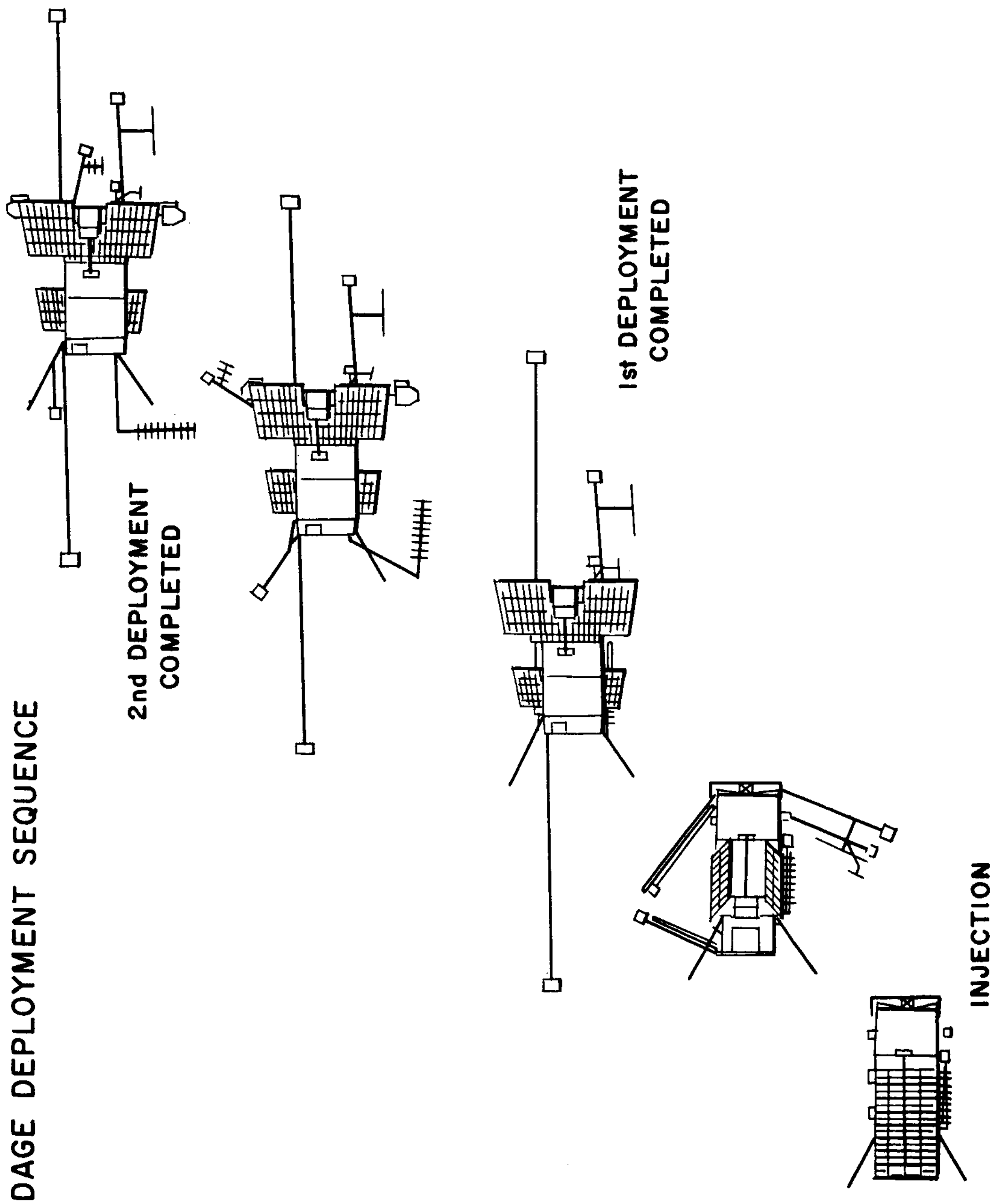
ORBITING GEOPHYSICAL OBSERVATORY
APPENDAGE DEPLOYMENT SEQUENCE



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